Research on preparation and physico-chemical properties of modified carbon materials from the point of view of practical application

Summary

In recent years a rapid growth in the field of advanced technologies including electronics, nanotechnology, biotechnology etc., can be observed. In a consequence, there is a necessity to improve materials being utilized in the production processes. Technology utilizes almost all elements including carbon. The application spectrum of this element substantially widened in last century. Now, carbon constitutes an individual field of science and covers materials known for a long time, as well as those discovered in recent decades. Among a range of carbon materials, carbons containing foreign species are of a special interest. Because modification by mean of loading of foreign elements often strongly influences properties, application area of such materials can be extended. Nevertheless, despite a long history and extensive research, modification processes of carbon materials are often associated with certain difficulties and saddled with undesirable side-effects. In some cases treatments lead to unsatisfactory products or materials obtained in several lots do not reveal repeatable properties. By these reasons this work deals with possibilities to overcome mentioned negative aspects. Besides investigations focused on improvement of known methods, research on novel techniques for loading of foreign species into carbon materials was undertaken. Thus, some carbon materials i. e. activated carbons containing TiO_2, copper-coated carbon fiber, and nitrogen-enriched activated carbons were researched by the author.

Preparation procedure and characterization of coal-based activated carbons supporting TiO_2 is presented. TiO_2-loaded activated carbons were prepared through impregnation of coals with TiO_2 precursor followed by traditional carbonization and activation. Decomposition of titanium precursor introduced into three raw coals of a different composition is described and illustrated by XRD patterns taken at different stages of the preparation. Influence of a coal rank and titanium supported on coals on the development of a mesoporous structure is shown. Moreover, influence of activation time on both the Ti content and the size of TiO_2 particles supported in activated carbons is studied. As found, in comparison with the traditional impregnation method done after activation, loading of TiO_2 through carbon precursor impregnation leads to stronger fixation of the titania on the activated carbon. This is reflected by lower susceptibility of TiO_2 to elution with water.

A novel method for preparation of metallic copper-coated carbon fiber is described. The raw material was prepared through blending of isotropic coal pitch with $CuBr_2$ followed by spinning. In this way a raw copper salt-blended fiber with uniform distribution of copper was obtained. The raw fiber was stabilized with air and next subjected to treatment with hydrogen at temperatures up to 1143 K. XRD and XPS analyses confirmed the presence of metallic copper in the resulted fiber. Additionally, the metal was detected (EPMA maps) predominantly on the surface of the fiber, and obtained coating was smooth and did not exhibit noticeable defects (SEM observations). On the base of obtained results the mechanism of copper diffusion over carbon volume is proposed. In addition some general guidelines concerning extending of the method to other materials are given.

In the last part of the work treatment of commercial activated carbons under elevated pressure with ammonia generated in situ from the stoichiometric mixture of NaOH and NH_4Cl is studied. As confirmed by results of X-ray photoelectron spectroscopy measurements, the treatment can be used for enriching of activated carbon with nitrogen, and the nitrogen content increase achieved by autoclave treatment at 473 K was comparable to the one obtained by treatment in dry ammonia atmosphere at 873 K under atmospheric pressure. Negligible changes in the BET area of activated carbon subjected to the treatment at elevated pressure were confirmed by nitrogen adsorption isotherms (77 K). This was distinct to the activated carbons treated with dry ammonia revealing significantly increased specific

surface area. The influence of the modification method on the structure of surface functional groups formed on activated carbons has been studied. Studies focused on the adsorption from both gas and liquid phases were also carried out. In contrast to raw activated carbons, adsorbents subjected to treatment with ammonia in most cases revealed enhanced adsorption of model acidic compounds used in the reasearch. Adsorbents treated in autolave and modified under atmospheric pressure (873 K) showed comparable efficiency in adsorption of phenol from water, and CO_2 and NO_2 from air. However, distinct to the thermal method, modification under elevated pressure did not result in an increase of SO_2 uptake from air.